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Editorial

Special issue on logics for intelligent agents and multi-agent systems

This issue reports on the latest developments in formal approaches to intelligent agents and multi-agent systems based on modal logics and their applications on various aspects of agency. Intelligent agents, be it on their own or as part of a multi-agent system, operate in a dynamic and complex environment and hence they need to be able to cope with uncertainty and reason with often incomplete information. Agents must interact and also cooperate with one another to be able to meet their intended goals. Formal approaches may assist the developers of agent-based systems in modelling and verifying that the actions of intelligents agents and multi-agent interactions will lead to a desirable outcome. In order to develop theories to specify and reason about various aspects of intelligent agents and multi-agent systems, many researchers have therefore proposed the use of modal logics such as logics of beliefs, knowledge, norms, obligations and time, as these are among the concepts that are critical to an understanding of intelligent agent behaviour.

This special issue arose from the inaugural international *Workshop on Logics for Intelligent Agents and Multi-Agent Systems (WLIAMAS 2008)* which was organised by Mehmet A. Orgun, Guido Governatori, Chuchang Liu, Mark Reynolds and Abdul Sattar. WLIAMAS 2008 was held in conjunction with *the IEEE/WIC/ACM International Conference on Intelligent Agent Technology (IAT 2008)* in Sydney, Australia in December 2008. This workshop series aims at bringing together researchers from the fields of modal logics, theoretical computer science and multi-agent systems as well as researchers and practitioners who are interested in building agent-based systems by drawing inspiration from various forms of modal logics. Therefore the affiliation of WLIAMAS with IAT was both timely and mutually beneficial for the communities involved in those events.

WLIAMAS 2008 received 21 full paper submissions each of which was reviewed by three program committee members of international standing. The selection process was very competitive and, as a result, six full papers were accepted for presentation and included in the proceedings of the conference published by the IEEE Computer Society. The workshop created a discussion forum and exchange medium for experts from the two fronts: developers and practitioners of agent-based systems and researchers who are interested in formal models of agency. Attendance at the workshop was well over 20 participants and after each presentation there was a lively discussion. It was felt that the first workshop was a great success and subsequently it led to two other successful workshops, namely, WLIAMAS 2009 and WLIAMAS 2010, which were held in conjunction with IAT 09 and IAT 10 respectively.

After the workshop, the authors of the papers presented at WLIAMAS 2008 were invited to submit a revised and significantly extended version of their papers for possible publication in a special issue of *Journal of Applied Logic*. The special issue was also open to the submission of papers which were not presented at WLIAMAS 2008. In response to the call for papers, we received seven high quality submissions which then went through a rigorous review process. Each submission was sent to at least two reviewers who are experts in agent research and closely related areas. Of the seven papers submitted to the special issue, five of them were finally accepted for publication. The accepted papers, which are summarised below, reflect several diverse but complementary approaches and applications of logics of agency and logics for multi-agent systems.

The first paper by Michael Fisher titled “Agent deliberation in an executable temporal framework” discusses the formal representation and implementation of deliberation within autonomous agents in an executable temporal logic. Agent behaviour is formally specified using temporal logic formulas which are then directly executed. A critical aspect of the work is the introduction of the $\diamond$ operator for modelling temporal indeterminacy in the future and hence allowing the agents to eventually fulfill their long-term plans. This work foreshadows a formal engineering approach to the development of agent-based systems that could complement the agent-oriented software engineering approach.

The second paper by Chuchang Liu, Angela Billard and Benjamin Long titled “An abstract dynamic access control architecture” proposes an abstract architecture for access control. The architecture is based on the access control security framework, defined by ISO/IEC (International Organization for Standardization/International Electrotechnical Commission) in 1996. The key contribution of the work is the model of a dynamic environment for access control in which a number of agents may be operating. Based on this model, the architecture supports the specification of access control policies in first-order temporal logic. The authors also discuss a model checking procedure for verifying the desired properties of access control policies.

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The third paper by Jeff Blee, David Billington, Guido Governatori and Abdul Sattar titled "Levels of modality for BDI logic" presents a system of multi-modal logic formalising degrees or levels of mental attitudes of intelligent agents such as belief, desire and intention (BDI). The celebrated BDI model of Bratman, and the BDI logic developed by Rao and Georgeff, provide a formal foundation for reasoning about rational agents by capturing those mental attitudes. The authors extend the BDI logic by introducing qualitative levels of beliefs, desires, and intentions, enabling a rational agent to employ commonsense reasoning. They demonstrate the practical potential of their system in scheduling by applying it to the problem of organising appointments for a personal assistant system.

The fourth paper by Antonino Rotolo, Guido Boella, Guido Governatori, Joris Hulstijn, Regis Riveret and Leendert van der Torre titled "Time and defeasibility in FIPA ACL semantics" proposes a defeasible logic extended with time and modal operators. The authors show how the proposed logic can be used for specifying and reasoning about communicative speech acts which are used in multi-agent systems to express the intent of an agent in its communication with the other agents. The authors focus on speech act message labelling standardised by the Foundation for Intelligent Physical Agents (FIPA) and provide a formal semantics for agent communication languages in their extended defeasible logic.

The fifth and the last paper by Ji Ma, Mehmet Orgun and Kamel Adi is entitled "An analytic tableau calculus for a temporalised belief logic". The temporalised belief logic discussed by the authors is obtained by adding a linear-time temporal logic onto a belief logic by the temporalisation method of Finger and Gabbay. The authors propose a complete labelled tableau calculus for the logic which is then used for reasoning about evolving beliefs of agents operating in dynamic, complex, and often uncertain, environments. They apply the tableau calculus for the verification of communication protocols formally captured as trust theories in the logic.

We hope that the breadth and diversity of the papers published in this special issue will foster further research on logics of agency and multi-agent systems ranging from philosophical, theoretical and practical issues to implementations of such logics and their promising applications.

This special issue would not have been possible without the contributions of numerous fine people. First, we are greatly indebted to Professor Dov Gabbay, for his continuing encouragement and support for the special issue. Thanks are also due to Jane Spurr, the Editorial Assistant of *Journal of Applied Logic*, for her enthusiasm and effective assistance during the production stage. Last but not the least, we are indebted to the authors who responded to the invitation to submit their papers, and the reviewers who generously donated their time and expertise and provided very comprehensive reviews of the submitted papers.

In closing, we would like to take this opportunity to commemorate Jeff Blee, the first author of the third paper, who fought bravely but lost his fight to cancer in 2010. Jeff entered Griffith University as a mature age student and completed his Bachelor's degree with aplomb having received several well-deserved awards, majors in Software Engineering, Artificial Intelligence and Computer Science and the highest GPA in his degree for that year. Jeff obtained a first class honours in the following year and won a University Medal. He was studying towards the PhD degree at Griffith University when he passed away. His paper is a testament to the quality of the research program he had been pursuing in his studies. Rest in peace Jeff, you will remain in our hearts.

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